Impact of Swine Manure Application on Water Quality

Ramesh Kanwar, professor
Carl Pederson, research associate
Matt Helmers, assistant professor
Department of Ag and Biosystems Engineering
John Sawyer, associate professor
Antonio Mallarino, professor
Department of Agronomy

Introduction

Nonpoint source nutrient pollution related to land application of manures is recognized as an important environmental and social issue for several reasons. First, swine manure application to land can impact water quality. Second, several states are in the process of creating laws and/or regulations to reduce nitrogen and phosphorus loadings from manure to soil and water resources. Third, the quality of water resources will help set parameters for developing public policies on management of manure.

To address public concerns about water quality from the use of swine manure as a source of crop nutrients (N and P), a long-term field study was initiated in 2000 with a grant from the Leopold Center for Sustainable Agriculture. This study is being conducted at the Iowa State University Northeast Research Farm, Nashua, IA. The site has 36, one-acre plots that are instrumented with devices to monitor subsurface drainage flows for continuous water quality assessment. These plots were established earlier in 1988 for another water quality study that was completed in 1998.

Objectives of the Study:

- To determine the impact of swine manure application rate based on N or P, on water quality.
- To study the long-term effects of swine manure application to both corn and soybean on crop yield and N and P losses with subsurface drainage.
- To compare spring and fall injection of swine manure on crop yield, and N and P concentrations in tile flow drainage.
- To develop and recommend appropriate manure and nutrient management practices to reduce the water contamination potential from manure and fertilizer N (UAN).

Progress Report for the Years 2000–2006:
In this ongoing seven-year study, we are evaluating the effects of six different nutrient management treatments on subsurface water quality. Table 1 lists the experimental treatments and intended N and P application rate for each treatment.

Treatments 1 and 2 compare the effect of 150-lb/acre application rate from liquid UAN and swine manure on water quality. Treatments 3 and 4 compare manure application rates based on approximate P removal in corn grain (with spring application of UAN to reach 150 lb total N/ac) with manure application each year to corn (150 lb manure-N/ac) and to soybean (200 lb manure-N/ac). Treatment 5 includes N-application rate of 150 lb/acre from UAN-fertilizer to corn using a Localized Compaction and Doming (LCD) applicator designed for potential improved N-uptake and reduced NO_3-N leaching. Treatment 6 includes spring application of liquid swine manure at an application rate of 150 lb N/acre in a no-tillage system using a new applicator designed for no-till conditions. Each treatment was replicated three times in a corn-soybean rotation. Soil and water samples from this study are analyzed for NO_3-N, PO_4-P, and bacteria to determine the effect of the six treatments on soil and water quality. Analyses of P concentrations in soil and tile drainage for recent years have not been completed at this time and will be summarized in a future report.

Tables 2 and 3 summarize experimental results from 2000–2006. Table 3 shows that Treatment 4 with fall manure application to corn resulted in the highest average corn yield (185 bu/ac) and an average soybean yield (59 bu/ac). Table 2 gives yearly average NO_3-N concentrations. Treatment 4, with swine manure applications each year to corn and soybean, resulted in the highest average NO_3-N concentration in tile water (39.8 mg/l). Treatment 6, with spring application of manure in no-till, resulted in the lowest average NO_3-N concentration (16.2 mg/l), and similar to the concentration with spring and sidedress UAN. However, average corn yields were lowest with the LCD sidedress UAN and spring no-till manure applications. These preliminary results indicate potential for management of swine manure application to reduce leaching of NO_3-N.

Table 1. Experimental treatments for the Nashua site.

Application timings and source of N	Crop	Application rate, lb/ac	
		N based rate	P_2O_5 based rate
1. Spring UAN	corn	150	60
	soybean	-	44
2. Fall manure	corn	150	-
	soybean	-	-
3. Fall P based manure/UAN	corn	150	60*
	soybean	-	44
4. Fall manure application to both corn and soybeans	corn	150	-
	soybean	200	-
5. UAN w/LCD (sidedress)	corn	150	60
	soybean	-	44
6. Spring manure (no-till)	corn	150	-
	soybean	-	-

*P-based: application rate of P from swine manure on the basis of P removal by corn

Table 2. Effects of experimental treatments on average NO_3-N concentrations (mg/l) in subsurface drain water.

Treatments	2001		2002		2003		2004		2005		2006		2001-2006	
	CS	SC	CS	SC	CS	SC	CS	SC	CS	SC	CS	SC	CS	SC
1. Spring UAN	14.2	18.8	11.4	18.8	21.7	18.2	30.2	18.6	19.2	16.4	13.9	12.5	18.4	17.2
2. Fall manure	24.9	15.8	16.9	19.3	26.8	16.1	36.5	20.0	26.1	14.0	19.7	16.2	25.1	16.9
3. Fall P based manure	16.9	12.7	8.8	16.1	21.6	16.3	33.1	20.4	24.7	15.8	17.4	15.2	20.4	16.1
4. Fall manure	25.9	31.5	31.8	20.7	29.4	44.6	70.4	50.1	40.8	43.2	40.5	29.6	39.8	36.6
5. UAN w/LCD	12.6	18.4	12.4	20.3	19.4	20.5	19.6	22.1	20.6	15.2	14.6	18.3	16.5	19.1
6. Spring manure	12.4	8.3	9.6	9.3	18.1	11.1	23.1	18.8	21.6	10.8	12.5	15.9	16.2	12.4

Table 3. Corn and soybean yields for all treatments.

Year	Spring UAN 150 lb N bu/ac		Fall manure 150 lb N bu/ac		Fall manure P based bu/ac		Fall manure both crops bu/ac		LCD UAN 150 lb N bu/ac		Spring manure 150 lb N bu/ac	
	C	S	C	S	C	S	C	S	C	S	C	S
2000	164	55	171	58	166	58	153	71	161	58	159	54
2001	163	46	177	51	173*	43	181	56	159	46	169	44
2002	192	54	194	56	191	57	194	59	189	54	192	53
2003	156	31	163	29	164	29	167	28	149	30	157	28
2004	205	60	196	59	202	59	203	56	205	59	185	56
2005	192	66	191	69	193	65	198	74	190	64	193	69
2006	197	62	200	62	195	65	197	65	198	62	188	63
Avg	181	53	184	55	184	54	185	59	179	53	177	52

*One replication discarded due to cutworm damage.